MANAGEMENT OF LARGE-SCALE TECHNOLOGY

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The history of the United States space program in the 1960s has the appeal of something conceived with magnificent simplicity and carried out on the grand scale. Between 1961 and 1970, the National Aeronautics and Space Administration (NASA) launched several dozen unmanned spacecraft, revolutionizing communications and meteorological technologies, on the one hand, and electronics and software development on the other. But in the public mind, NASA was most closely associated with the manned spaceflight programs—Project Mercury (1958-1963), which tested the ability of one man to function up to several hours in Earth orbit; Gemini (1962-1966), in which two men in one spacecraft were assigned a variety of tasks, including rendezvous and docking in Earth orbit with a target vehicle and moving around outside the spacecraft itself, and Apollo (1961-1972), wherein three-man crews were sent on progressively more ambitious missions, culminating in the lunar landing of July 1969. Merely to sketch the civilian space program thus is to indicate the magnitude of NASA assignments and the scope of its successes. One must take seriously the contention of James E. Webb, NASA Administrator from 1961 to 1968, that the success of NASA was a success in organizing "large-scale endeavors," i.e., that the same system of management that made the lunar landings possible may also have been their most important byproduct.

In this paper, I am going to try to answer the following question: What can the study of NASA, as an organization, teach us? Using Webb's concept of the large-scale endeavor as a starting point, I will concentrate on NASA as a going concern; in other words, as an organization that, instituted for specific purposes, strove to maintain itself, to operate within the terms of its establishment, and to compete with other agencies for the limited resources made available by Congress and the White House. Put differently, themes running through this paper will be: (1) how a high-technology agency was run in a decade marked by rapid expansion of funds and manpower in the first half and almost as rapid contraction in the second; and (2) how NASA combined centralized planning and control with decentralized project execution. In turn, each of these themes raises subsidiary questions: What criteria did the agency use in choosing its contractors and, in the absence of market conditions, how did it supervise them to get the hardware and services for which it contracted? How did NASA maintain its independence vis-à-vis the Department of

Defense (DoD), the one federal agency with which NASA had to come to terms?

The concept of the large-scale endeavor is useful but, at the same time, difficult to pin down. In his *Space Age Management*, drafted in his last months at NASA and published shortly after he resigned as administrator, Webb discussed the characteristics of the large-scale endeavor. Typically, the endeavor results from a new and urgent need or a new opportunity created by social, political, technological, or military changes in the environment. Most often, it requires "doing something for the first time and [has] a high degree of uncertainty as to precise results," and it will have second- and third-order consequences, often unintended, beyond the main objective.[1] Finally, such endeavors "do not generally require new organizational and administrative forms, but the more effective utilization of existing forms." [2] Webb's description can, of course, apply to many endeavors beside the space program; the attempt to build and operate a national rail passenger network, to develop a strategic petroleum reserve, to build the Alaska pipeline, or to conduct the War on Poverty—all share many of the features Webb enumerates. But the space program and the projects comprising it had certain advantages in attaining its goals, stemming from the nature of its mission, which most of the endeavors named above lacked.

First, the NASA goals could be stated in precise, operational terms. The agency would describe a goal within the broader mission: put a communications satellite in synchronous Earth orbit; or, develop an unmanned spacecraft to soft-land on the Moon and a vehicle with a liquid-hydrogen upper stage to launch it. Such precision may be contrasted with those federal agencies charged with improving the quality of education, fighting alcoholism and drug abuse, or finding permanent jobs for the hard-core unemployed. As Charles Lindblom and David Cohen have noted, "Government agencies are again and again assigned . . . responsibilities beyond any person's or organization's known competence. They do not typically resist these assignments because they are funded and maintained for their efforts, not for their results." [3]

Second, NASA in the early 1960s had an organizational flexibility unmatched by any agency of comparable size. In this period NASA had no formal agency-wide long-range plan; no general advisory committee of outside scientists, such as those established for the Atomic Energy Commission and the Department of Defense; no inspector-general, chief scientist, or chief engineer; no centralized range structure for tracking, data acquisition, and mission control; no central planning staff attached to the Office of the Administrator. These functions were handled in

other, much more decentralized ways. Moreover, the absence of a plan or general advisory committee rescued the agency from becoming captive to policies which might cease to be relevant. To maintain this flexibility and to adapt the agency to change, there were frequent reorganizations, notably in 1961, 1963, 1965, and 1967. But they were not ends in themselves. They were designed less to set certain things right—for instance, to improve communications between decision-makers and their supporting staffs, or to free the field centers from unneeded supervision—than to turn the agency from one set of programs to those of quite a different sort. For NASA was vulnerable. It had to stake a claim to territory of its own, rather than becoming (as its predecessor, the National Advisory Committee for Aeronautics, had been) a supporting arm of the military services, or a supervisory agency with a small in-house staff and contractor-operated facilities, like the Atomic Energy Commission.

Finally, NASA in the 1960s was an agency with a single mission—to land a man on the Moon and return him safely before the end of the decade—but with numerous subordinate goals. The National Aeronautics and Space Act enacted by Congress in July 1958 was permissive rather than mandatory, so far as ends were concerned. It was a shopping list as much as an enabling act, freeing NASA to pursue those programs that were at once technically possible, politically feasible, and challenging enough to enlist the support of key technical personnel. So that the agency might keep abreast of technical developments, NASA officials thought it necessary to develop capabilities in basic research or in propulsion that were independent of any specific mission or use. This policy lessened the danger, noted in a 1966 Senate report, that "there may be a penalty attached to the 'approved mission' policy for advanced development. Premature obsolescence is one hazard. Commitment of resources before the full cost-benefit is another. The narrowing of component and subsystem engineering is a third." [4]

But the conditions I have listed do not explain NASA's success in managing large-scale technology. Precise goals and organizational flexibility help to set the rules of the game; they define, as it were, a policy space in which NASA could manage its programs. To show how NASA managers worked within that policy space, I want to discuss three areas: the problems faced and met in setting up a headquarters organization; selecting contractors who could operate in the peculiar environment of very large research and development (R&D) programs; and the means by which NASA kept the military at arm's length, while receiving the support necessary to launch and track Mercury, Gemini, and Apollo. These areas, it seems to me, can tell a great deal about the success of NASA's ap-

proach to getting its R&D work done. In the final section of this paper, I will mention some of the lessons learned and the extent to which NASA can serve as a precedent for other large-scale endeavors.

Headquarters-Center Relations

Established by Congress in the aftermath of *Sputniks 1* and *2*, NASA quickly grew by accretion, the incorporation of older installations, and the creation of new capabilities into an agency with 36,000 civil service employees and a budget of $5.5 billion by 1965-1966. Indeed, by 1962, NASA had taken on most of the features it possesses today. It was headed by an Administrator supported by a Deputy and an Associate Administrator; together, these officials comprised the agency's top management. Under them were bureaus with agency-wide functional responsibilities for procurement, budget preparation, personnel, public affairs, and legislative affairs. Additionally, there were four program offices, each headed by an Associate Administrator and responsible for NASA's substantive programs. From 1963, these offices were: Space Science and Applications; Manned Space Flight, which was responsible for Mercury, Gemini, Apollo, and the follow-on to Apollo that became Skylab; Advanced Research and Technology, which managed NASA's aeronautical research, as well as the supporting research for the other program offices; and the Office of Tracking and Data Acquisition. All of the field centers reported directly to the program offices. Thus the Marshall Space Flight Center in Huntsville, Alabama, the Kennedy Space Center at Cape Canaveral, and the Manned Spacecraft Center at Houston all reported to the Associate Administrator for Manned Space Flight. The older research centers which predated NASA reported to the Office for Advanced Research and Technology, while the Goddard Space Flight Center in the Maryland suburbs of Washington reported to the Office of Space Science and Applications. There was one other installation that was unique. This was the Jet Propulsion Laboratory in Pasadena, California, which was operated by the California Institute of Technology under contract to NASA. JPL was (and still is) responsible for managing NASA's deep space and interplanetary probes and, consequently, reported to the Office of Space Science and Applications.

Clearly, a summary of names and reporting responsibilities tells very little about relations between headquarters and the field centers. The tension between headquarters and the centers was built into NASA. Headquarters, itself almost a kind of rival installation, had certain key functions: to prepare and defend the agency budget, to allocate funds for

R&D and the construction of facilities, and to serve as a central control point. Beyond this, there were problems which senior management could hope to resolve only after years of trial and error. One of these was whether the centers should report directly to the agency's general manager—the Associate Administrator—or to the heads of the program offices. The first approach was the logical solution when the centers were involved in a variety of projects; the second, when each center had a carefully defined task distinct from the other centers. Another problem was how centers reporting to one office could work with those reporting to another. A third was the problem of project assignment: whether to give the entire project to one center, split it between the centers and designate one as "lead," or put the entire project management team in headquarters. A fourth problem was how to convert the older research-oriented institutions into managers of large development contracts. And all of these problems were compounded by the difficulties faced by headquarters and the centers in communicating with each other. The greater the pressures of time, the faster the rate of significant change in the environment; the more interrelated the various programs, the more difficult and necessary adequate communications would be.

Yet, by the end of 1963, all of these problems had been provisionally solved. NASA's top officials stressed that project management was the field installations' responsibility and that, within certain limitations imposed by Congress, directors and project managers could move some funds from one budget category to another. For all flight projects except Apollo, there was to be one lead center, regardless of how many installations actually participated. The tools for getting the job done would be grouped in related fashion. Thus the Office of Applications, which used the same launch vehicles and centers as Space Sciences, merged with it in 1963. Each center was to have the capacity to manage large development contracts, and, if necessary, assign projects for which new skills would have to be recruited; the skills to integrate the subsystems of a project parcelled out among two or three different centers; and the ability to draw on the resources of other centers instead of duplicating them needlessly. Concurrent with the change by which the centers reported directly to the program offices, NASA instituted two other reforms which greatly improved operations. It unified all launch operations at Cape Canaveral, where previously each center had had its own launch team; and it established intensive monthly status reviews, at which Associate Administrator Robert Seamans would sit down with the heads of the program offices to review planned versus actual allocations, at the centers and at contractor plants; planned versus actual expenditures; milestones in

program and procurement schedules; and advanced studies prior to their completion. These recurring meetings enabled top officials to use overlapping sources of information, give all points of view an airing, and eliminate the middleman in channeling information upward.

NASA Procurement Strategies

Next to the ordering of headquarters-center relations and inseparable from it, the most important decision made by NASA officials was to rely on private industry rather than in-house staff to implement its R&D programs. Contractors were involved at every stage of R&D and for every purpose, from the preparation of advanced studies to systems engineering, manufacture of hardware, checkout of flight equipment, operation of tracking stations, etc. From the outset NASA chose to follow the Air Force and the Atomic Energy Commission in contracting out; in particular, the Air Force and its intercontinental ballistic missile (ICBM) programs were the only programs since the Manhattan Project comparable to the NASA mission. Both ICBM and Apollo had in common technological complexity, tight time schedules, unusual reliability requirements, a general absence of quantity, and little follow-on production. Although some 20,000 firms were working on Apollo in the mid-1960s, a 1969 study showed that NASA had bought only 20 Mercury, 13 Gemini, and 38 Apollo spacecraft including test models and spacecraft modified for changed mission objectives. NASA usually had to contract for products whose main features could not be precisely defined in advance, so that there was no clear-cut basis on which the bidder could make realistic cost estimates. For R&D programs of this sort, NASA waived formal advertising in favor of negotiations with selected bidders.

Viewed in this light, the rationale for an in-house technical staff was to enable NASA to retain those functions that, it has been said, no government agency has the right to contract out, functions enumerated by a former Director of the Bureau of the Budget as "the decisions on what work is to be done, what objectives are to be set for the work, what time period and what costs are to be associated with the work, what the results expected are to be . . . the evaluation and the responsibilities for knowing whether the work has gone as it was supposed to go, and if it has not, what went wrong, and how it can be corrected on subsequent occasions." [5] This, in fact, was NASA's position: that the rapid buildup of the Gemini and Apollo programs precluded reliance on government employees alone; that it was agency policy not to develop in-house capabilities already available in the private sector; that NASA employees were needed for technical direction rather than for hardware fabrication or

routine chores; that NASA had developed safeguards for policing its contractors; that it was better to let the up-and-down swings in manpower take place in the contractor, rather than the civil service, work force; and finally, that the practice of using support-service contractors had been fully disclosed to Congress and the Bureau of the Budget. NASA was prepared to go even further. When Congress and the White House began to cut NASA's budget from 1967 on, NASA laid off its own employees at several centers before dismissing contract workers. More remarkable still, NASA's position has been sustained in the federal courts and would seem to have government-wide application.

In the short run, NASA's use of negotiated competition for large R&D contracts must be judged a success. It enabled NASA to assemble manpower—some 420,000 contract and government employees in 1966—and disperse it gradually as the manned space program phased down. It tapped capabilities already available, and saved NASA from having to develop those same capabilities from scratch. Since the largest prime contracts—those for the Apollo spacecraft or the Saturn rocket, for example—required thousands of subcontractors, NASA's R&D monies were spread over much of the United States, so enlarging the agency's clientele. But the system had serious weaknesses. Despite the introduction of incentive provisions and the negotiation of contracts for successive phases of the R&D process—phased project planning—NASA was unable, despite the most strenuous efforts, to police its contractors. The idea behind incentives was to reward the contractor for staying within cost and on schedule and to penalize it for falling short. But while incentives might reduce they could not eliminate the technical uncertainties dogging most R&D programs. A contract designed to cover everything from the early development phases to small-quantity production was not flexible enough for the kind of program where the end item changed over the life of the program. The contradiction between fixed targets and changing programs was not easy to reconcile. Moreover, the sheer size of these programs made it exceedingly difficult to find out what was going on in the field. NASA did not even pretend to review work below the first tier of subcontractors. NASA's inability or unwillingness to force its contractors to make major design changes led to the January 1967 fire which killed three astronauts and caused the Apollo program to slip 18 months.

Another flaw in NASA's procurement system was that competition for major contracts dwindled in the 1960s. There is reason to believe that NASA chose competitively more frequently in the late 1950s and early 1960s than it did later. It may be that by 1965 there were fewer new

systems on which to bid, or that the high cost of entry locked out prospective competitors. It was not only expensive to get into the space business but even more expensive to stay in; thus Grumman, NASA's number two prime contractor during the later 1960s, virtually withdrew from space systems after completing its work on the lunar module and the Orbiting Astronomical Observatories, both of which were plagued with overruns and technical difficulties. And as aerospace firms merged or were bought up by competitors, NASA found itself locked into an industry structure for which it was partly responsible.

Finally, even in the 1960s NASA did not have all the in-house skills it would have needed to provide its contractors with complete technical direction. NASA had to call in Boeing to integrate the Apollo spacecraft with the Saturn V launch vehicle; General Electric, to check out flight equipment at Cape Canaveral; AT&T, to set up a wholly-owned subsidiary to do systems engineering and long-range planning for NASA. It must be stressed that NASA, in the Apollo program, possessed a far greater depth of experience and talent than the Air Force's laboratories or the Special Projects Office that developed the Navy's Polaris. NASA personnel determined the conditions under which contracting would be necessary, anticipated problems before the contractor, reviewed the contractor's work, and terminated the contract. But there were areas where NASA engineers did not have the same degree of competence as their contractors, and where NASA had little choice but to accept the contractor's analysis. This was the case when NASA had more than 35,000 employees. In the era of the Space Shuttle, NASA, with perhaps 40 percent fewer employees, probably has less real control, less ability to change the scope of work, than it had 15 years ago.

NASA-Defense Relations

The final area I would like to discuss is NASA's relations with the Department of Defense. Units such as the Defense Supply Agency, which administered many NASA contracts, the Army Corps of Engineers, which managed NASA's largest construction projects, and the Air Force, which detailed officers to serve as program managers and directors of center operating divisions—all of these provided essential support to the agency. This was in addition to the early, once-only transfers of launch vehicles like Saturn, spacecraft like Tiros, contractor-operated facilities like the Jet Propulsion Laboratory, and the technical skills of Wernher von Braun's team of engineers. Simply to list examples, however, gives only the barest

hint of the significance, for NASA, of the totality of such support. The essence of the NASA-DoD relationship had far more to do with mutual need than with philosophical arguments concerning the existence or the desirability of one space program or two. The Space Act itself could only outline the scope of interagency relations in the most general way. The act declared that, while aeronautical and space programs would be managed by a civilian agency, "activities peculiar to or primarily associated with the development of weapons systems . . . or the defense of the United States" would remain DoD's responsibility; and it enjoined NASA to make available "to agencies directly concerned with national defense . . . discoveries that have military value or significance." It is well, then, to set aside preconceptions. "Civilian" and "military" were not the same as "peaceful" and "non-peaceful"; duplication of programs could be "warranted" or "unwarranted"; while much of the struggle over the military uses of space was as much between elements within DoD as between DoD and NASA.

The principles underlying the U.S. space program resulted less from anything enunciated in the Space Act than from President Kennedy's decision in May 1961 to assign the lunar-landing program to NASA. But this decision was preceded by earlier moves by NASA and DoD officials and by Congress to prevent an Air Force takeover. Three of these moves were particularly important: the agreements ratified by Webb and civilian Defense and Air Force officials which laid the ground for further cooperation; the March 1961 order of Secretary of Defense Robert McNamara which, by assigning most DoD space programs to the Air Force, thereby gave the Secretary tighter control over all military space operations; and the pressure exerted by the House Committee on Science and Astronautics, which authorized NASA's budget, to give NASA the lion's share of manned space programs. With the backing of the President and much of Congress and the acquiescence of McNamara, NASA, on the one hand, staked out its position as an independent agency while, on the other, waging a quiet behind-the-scenes battle with DoD to maintain that independence. Beginning as an agency heavily dependent on DoD support, NASA succeeded in freeing itself from overt DoD control by 1963. Whether it was the management of Gemini, the management of what became the Kennedy Space Center, or the existence of colocated NASA and DoD tracking stations, the pattern was the same. NASA would cooperate with DoD, but never to the point of giving away its authority to meet its needs. NASA asserted its right to modify military launch vehicles to serve as boosters, let contracts to firms already heavily involved in defense work, and conducted advanced studies on manned

space stations at the same time that DoD was trying to develop its own Manned Orbiting Laboratory.

During NASA's first three years, the Air Force went to considerable lengths to become the dominant partner in the national space program. Even some years later the director of NASA's Office of Defense Affairs could observe that "the Air Force is inclined to look upon NASA as a competitor rather than a partner in the field of space." By 1963, however, the Air Force needed NASA almost as much as NASA needed the Air Force. NASA was doing important research in the life sciences and propulsion, and its centers had test facilities that the services needed badly. The framework within which the two agencies had to coexist had to accommodate many arrangements: whether it was a program managed by one agency with the other sharing in the planning of experiments; a joint program; a program started by one agency and transferred to the other; a joint program mostly funded by one agency; or programs whose success depended on the functioning of separate, cooperating systems. The preconditions for cooperation were that DoD accept NASA's definition of a coordinated program as one where concurrence was "not required as a pre-condition to further action" and that both agencies should centralize the organization of their space and launch vehicle programs to make cooperation possible. Between 1960 and 1963, these conditions were met.

The Lessons Learned

The conclusion I wish to draw from these cases is that NASA's remarkable success in managing R&D depended on the ability of the agency's top officials to enunciate goals, to shape the agency from within, to delegate to the program offices and centers the authority to get the job done, and to keep DoD at arm's length. Once NASA began to lose the support of the White House and Congress—roughly from 1967—the difficulty of running the agency became much greater and NASA began to resemble any other large government organization which redoubles its effort as it forgets its aim. The same combination of organizational and political elements which made for success in the first half of the 1960s could not stay the reduction and cancellations extending from 1967 almost to the present.

Timing Matters

In 1961, NASA was still a loosely-structured agency whose field centers worked in relative isolation from each other and from headquarters. The lunar-landing mission demanded much greater coordination—and for the time being, greater centralization—than had been the

case. One of the most important aspects of the Apollo program was the speed with which the crucial administrative and program decisions were made and the major prime contracts awarded. Except for the decision to go to all-up testing (the testing of all the major Apollo components together), the principal Apollo program decisions were made between August 1961 and the end of July 1962. Had they been stretched out over a longer period, it seems unlikely that they would have received the support that they did. A comparison between the establishment of the Manned Spacecraft Center (MSC) and the Electronics Research Center (ERC) in Cambridge, Massachusetts, will bring this out. NASA announced the selection of Houston as the site of the former after a brief survey. Yet the creation of the center generated powerful political support; the site itself was well located in relation to Huntsville and the Cape; and the reasons given for establishing a new center were justified in relation to the Apollo mission. In contrast, almost two years elapsed between the decision to establish the ERC and its formal establishment. There was no such consensus as existed in the case of MSC; NASA could not convince Congress or the public that a capability in electronics research was as vital to the agency as one to develop the Apollo spacecraft. The point is that the agency's top officials made the important decisions while there was time to do so. The 1961 reorganization had to be reversed two years later, but it gave NASA management the opportunity to bring the centers under tighter control than before.

The Importance of Flexibility

Another element in the success of the NASA organization was flexibility: flexibility for the Administrator to appoint to excepted positions, to award major R&D contracts without competitive bidding, to reprogram funds within appropriation accounts and to transfer between them, to devise and administer a custom-tailored entrance examination, etc. Examples such as these represent flexibility within the system, not a departure from it; departures from the norm were allowed by Congress, the Bureau of the Budget, and the Civil Service Commission. This flexibility allowed for that "free play of the joints" without which institutional *rigor mortis* sets in. The use of excepted positions, for example, served not only to promote employees from within, but also to bring in new blood and to expose NASA to outside influences. Similarly, without the authority to negotiate major contracts, it is unlikely that the lunar landing would have occurred on schedule. Indeed, this authority was probably more important than the introduction of incentive provisions from 1962 on. Incentives were difficult to administer: they required a

great deal of manpower and paperwork, the criteria for incentive payments were hard to pin down, and there was a contradiction inherent in fixing targets for changing programs. NASA management might well have awarded development contracts without adding incentive provisions. But it is hard to imagine Gemini, Apollo, or the orbiting observatories becoming operational had the agency been bound by competitive bidding or other rules that would have constrained its ability to choose its sources. The flexibility available to NASA depended on congressional willingness to tolerate practices that the legislature might have disallowed elsewhere. And when that toleration ceased, NASA fell victim to red tape and the bureaucratic tendency to review everything at least twice. By 1969, for instance, it took an average of 420 days to process a contract involving a procurement plan, 3 months for headquarters to review the plan, and 47 days for headquarters to approve a negotiated contract.

Politics and Effective Strategy

NASA management saw its responsibilities in political terms. The agency's top officials took it upon themselves to justify NASA where it mattered most—to the Bureau of the Budget, whose fiscal authorities set the terms of the annual budget request, and to Congress, which had to authorize the entire space program annually. What Harvey Sapolsky has said about Polaris surely applies here: "Competitors had to be eliminated; reviewing agencies had to be outmaneuvered; congressmen. . . , newspapermen and academicians had to be co-opted. Politics is a systemic requirement. What distinguishes programs in government is not that some play politics and others do not, but, rather, that some are better at it than others." [6] Thus the history of NASA from its establishment to the mid-1960s can be charted in terms of NASA's ability to design its own programs, procure its hardware, and support its spacecraft without overt interference from the military. The transfer of the Jet Propulsion Laboratory and the von Braun team to NASA, the 1961 cooperative agreements on the development of launch vehicles, President Kennedy's decision to assign the lunar mission to a civilian agency, and the 1963 agreement by which DoD acknowledged NASA as lead agency in Gemini, all represent stages by which NASA asserted its determination to run the agency as its officials saw fit. Not that interagency relations can be easily categorized. While most relations can be seen to fall into the categories of support, coordination, and rivalry, there were some that did not fit neatly into any category. There were others, like Gemini, that tended to become more like joint programs over time; while a program like the Manned Orbiting Laboratory was, in some ways, competitive with

Apollo, although the former relied heavily on NASA technology and ground support. Nevertheless, without a strong assertion of independence, NASA would have become what the services anticipated on the eve of the Space Act—a research agency supporting military projects.

The political strategies of NASA management were fourfold: to maintain NASA's independent status as an agency doing R&D; to curb outside interference by advisory and coordinating groups; to seek the approval of Congress in actions that the agency was about to take; and to limit NASA's support for other agencies, the better to concentrate its resources on Gemini and Apollo. NASA's relations with DoD are an example of the first type of strategy; its conflicts with the Space Science Board of the National Academy of Sciences is an example of the second; while NASA's position on the supersonic transport—to maintain an essentially supporting role to the Federal Aviation Administration—reflected the desire of Webb and Deputy Administrator Hugh Dryden not to strain NASA resources to the limit. Additionally, Webb dismantled the office that prepared the NASA long-range plan, precisely to avoid premature commitment to something beyond Apollo.

The Centers and Apollo

As mentioned before, NASA was remarkably decentralized for so large an agency. Perhaps it would be more accurate to say that programs such as Apollo or the orbiting observatories could not have been managed without the delegation of authority to the centers and the Jet Propulsion Laboratory—authority to negotiate contracts up to a specified amount, to transfer funds between programs, to start new research tasks without seeking specific authorization, to shift manpower from one division to another. The strategy of senior management was to give the centers what they needed to get the job done, but not so much that their work would lose its relevance to the agency's mission. During the 1960s, the "research" and "development" centers tended to become more like each other; centers reporting to one program office began to work for others; while those centers with a mixture of projects weathered the budget cuts at the end of the decade better than those with one or two large development programs that were phasing down. One of the most important by-products of Apollo was the pressure it placed on the older centers to get into development work. It was not so much a matter of pressure from headquarters as pressure from within the centers themselves that brought about this change. One wonders if the older centers had much choice; had they remained research centers and nothing else, they would very

likely have dwindled into insignificance. The centers had, so to speak, to latch on to the coattails of Apollo.

By 1969, most of the centers, particularly Marshall, were in the early phases of a "withdrawal process" brought on by cuts in manpower and funds. The problem of new roles and missions could be alleviated by the centers, but only in part. NASA officials conceded in principle that a less-than-best laboratory might be closed: if it had served its initial purpose; if there was no likelihood that a new role for the laboratory could be found; if the closing down of the laboratory would not leave a significant gap in the national capability to do R&D work. But most of the centers were adaptable and nearly all had gone through at least one reorganization in the late 1950s or early 1960s, moving from aeronautics to launch-vehicle development, or from development work on guided missiles to lunar and planetary probes, as with the Jet Propulsion Laboratory. By 1969, another cycle of reorganization was under way, as facilities that were no longer needed closed down, others were modified to accommodate new programs, while new facilities like the Lunar Receiving Laboratory at Houston became accomplished facts. Yet the more subtle changes in a center's mission could only occur very gradually. And here, it seems, the failure of headquarters to draft a coherent long-range plan left the centers at a serious disadvantage. The advanced studies and task force reports of 1964-1969 were no substitute for a NASA-wide plan. There were too many planning groups, with little coordination between them; a lack of interest among the centers; and the artificial forcing of the planning process by the creation of President Nixon's Space Task Group early in 1969. Still, top management might have done more to bring the process to some visible result inside the agency. In particular, not enough was done to relate substantive programs to any institutional framework.

In sum, NASA thrived during the early 1960s because of four elements within, or conferred upon, the organization: administrative flexibility; the ability of senior management to play the political game on the Hill, at the White House, and before the public at large; the delegation of program management to the field; and the timeliness with which the important decisions were made. But the same elements were not enough to enable NASA to weather the severest test to which any large mission-oriented agency can be put: namely, how to react to the completion of the original mission. It remains to be seen whether the Space Shuttle will be a truly radical departure for the U.S. space program or an example of an R&D program pushed through development long after evidence accumulated that the mission was not an attractive one.

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COMMENTARY

I.B. Holley, Jr.

As a rural New Englander brought up on the prudential ethic, "eat it up, wear it out, make it do, do without," I used to be shocked when I read about the profligate banking practices of the Jacksonian era. I was inclined to look down my nose at an administration that permitted the irresponsible issue of ill-secured bank notes. Then some years ago I read an essay by Joseph A. Schumpeter which put the problem in a whole new perspective. Inflationary emissions of paper in that capital-starved era were not simply a matter of policy, Schumpeter pointed out; they were a necessity. In the 1830s, government, at all echelons, lacked the necessary tools: the bureaucratic apparatus, to impose and enforce regulatory controls—even if it had been decided, as a matter of policy, that such controls were necessary.

As it says in the cigarette advertisements, "We've come a long way, baby." For those of you in the audience who are under 30, it may not be so evident how far we've come in the way of perfecting governmental apparatus just since the beginning of the space age. And I date this from the launching of V-2 rockets by the Nazis in World War II. In a sense, the first 20 years in space is a tale of advancing bureaucratic competence, and each of the papers presented here offers testimony on that theme.

In my commentary on the interesting papers we have just heard, I shall take them in reverse order, beginning with Arnold Levine's.